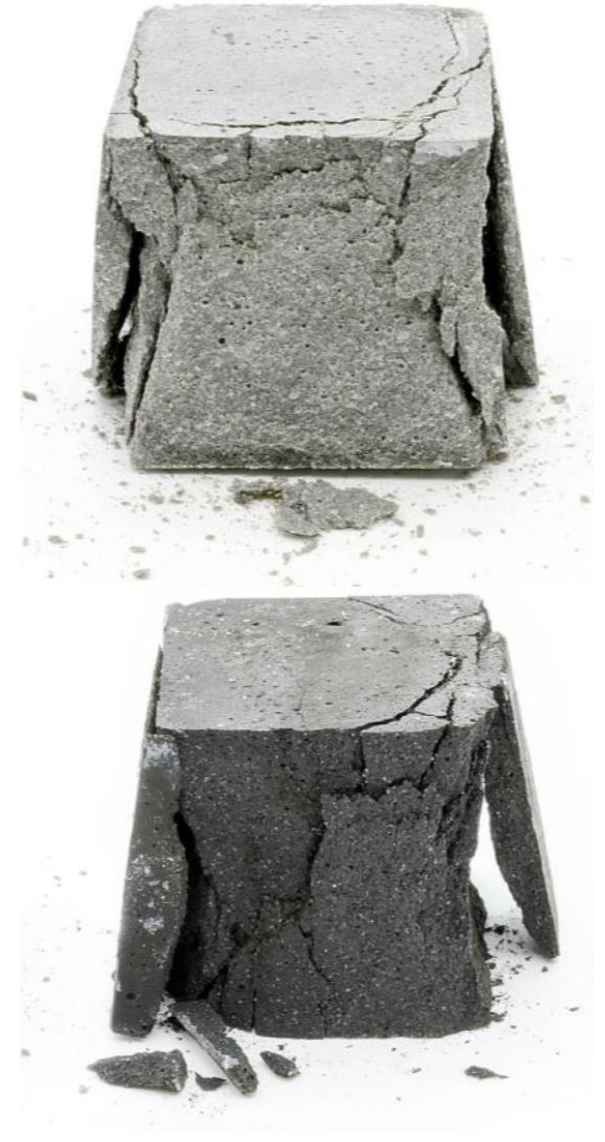


# HESTIA Kickoff Meeting



**High-Performing Carbon-Negative Concrete Using  
Low-Value Byproducts From Biofuels Production**

Wale Odukomaiya, NREL



# Technical Overview

- ▶ Project Team:
  - NREL (PI: Wale Odukumaiya)
  - Carbon Upcycling (Co-PI: Apoorv Sinha)
  - CU Boulder (Co-PI: Mija Hubler)
  - Colorado School of Mines (Co-PI: Lori Tunstall)
- ▶ Project Description:
  - Carbon-negative 'LignoCrete' by utilizing atmospheric CO<sub>2</sub> from agricultural residues and direct carbon utilization
  - Combines two highest potential cement GHG mitigation approaches into one concept

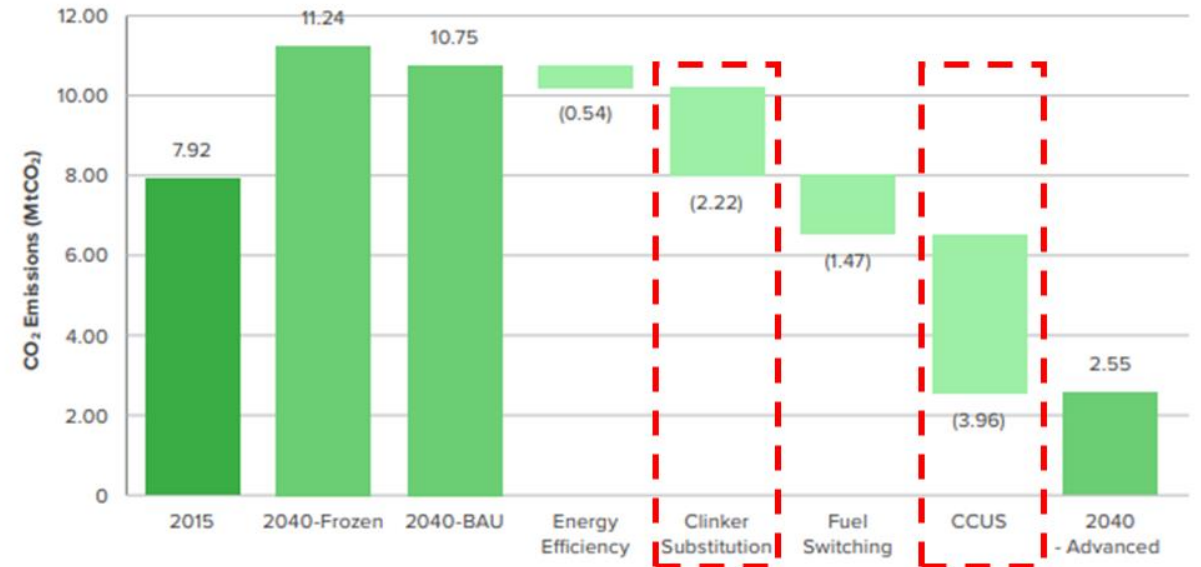
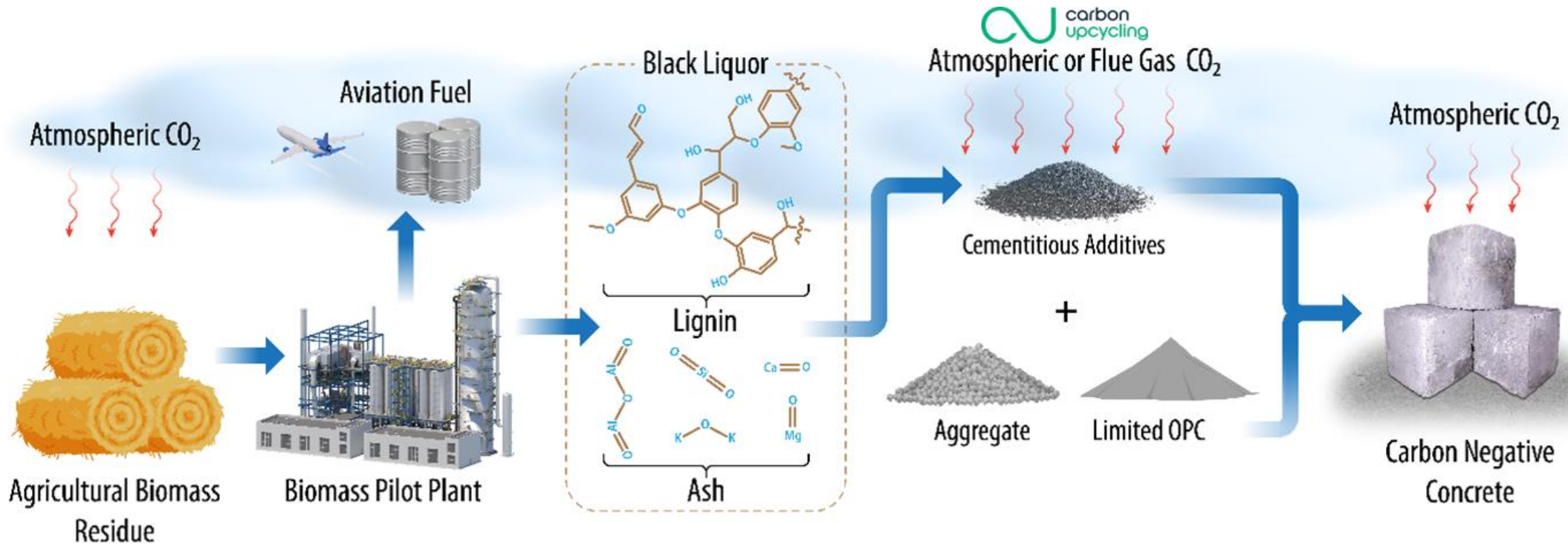


Figure ES 2. The impact of CO<sub>2</sub> emissions reduction levers on emissions from California's cement industry up to 2040

Material	Price Range (\$/ton)	Estimated U.S. Availability	Rival Uses
Fly Ash	~35—110	25.5 Mt/y	Yes
Slag	<1—110	14 Mt/y	Yes

Current materials used for clinker substitution

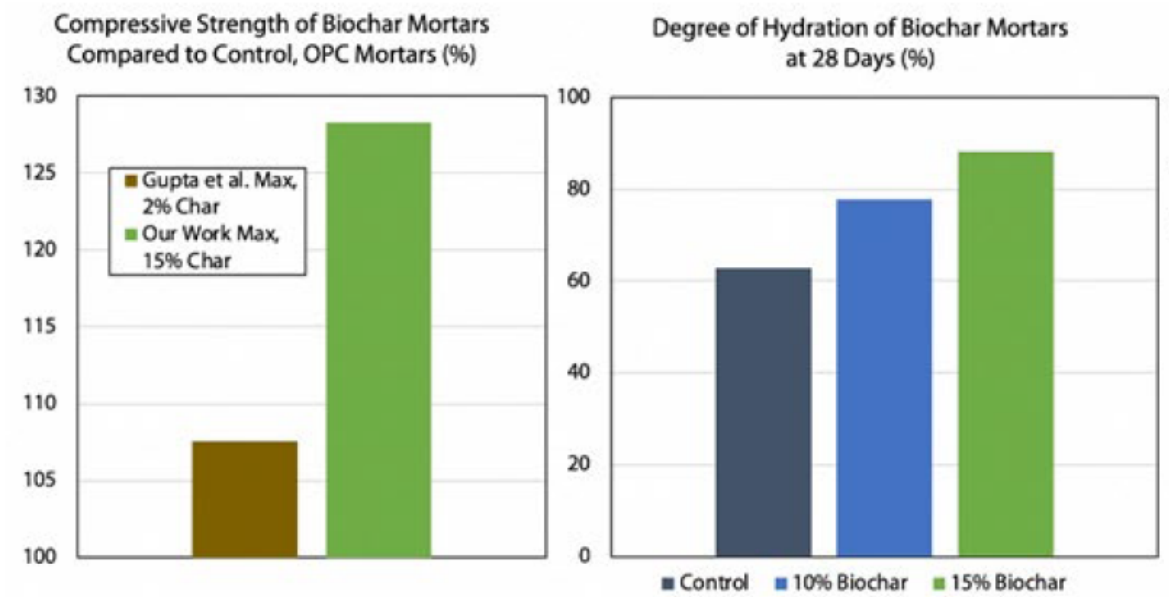
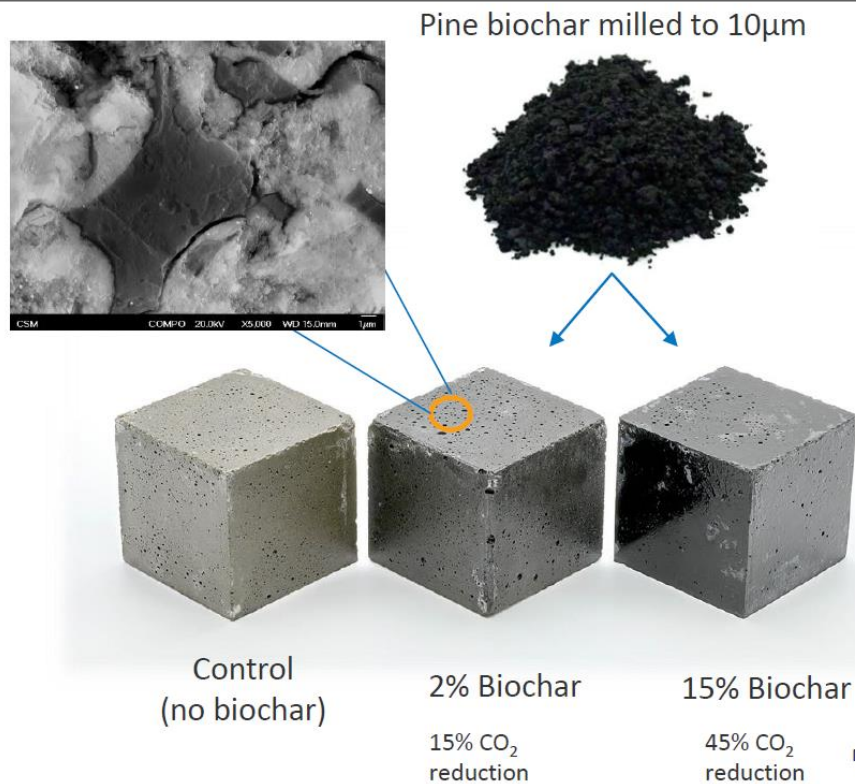
# Technical Overview



## Technology Summary

- We will develop two low carbon/carbon-negative concrete supplementary cementitious materials (SCMs), and a carbon-negative thermally insulative admixture using lignin-rich black liquor byproducts from sustainable aviation fuel production.
- These SCMs and admixture will be  $CO_2$  enhanced using Carbon Upcycling's MACE technology, improving performance and sequestering additional  $CO_2$ .
- The SCMs and admixture will be combined with aggregate and a limited amount of portland cement to create a carbon-negative **LignoCrete**.

# Project Impact



## Technology Impact

The US consumed ~102 megatons of cement in 2020. **LignoCrete** could replace 20-60 megatons per year.

This technology will: (1) displace OPC and heavy industry-based SCMs with low carbon/carbon-negative biobased SCMs, and (2) providing overall industry acceptance—through strategic industrial partnerships—of these novel classes of SCMs and additives for cementitious materials.

## Proposed Targets

Metric	State of the Art (OPC concrete)	Proposed (LignoCrete)
GHG emissions per cubic yard of concrete	190-210 kg CO <sub>2,eq</sub> /yd <sup>3</sup>	-10-50 kg CO <sub>2,eq</sub> /yd <sup>3</sup>
Thermal conductivity	1.4-2.3 W/(m*K)	<0.7 W/(m*K)
Compressive strength	20+ MPa	20+ MPa
Material cost	~\$62/yd <sup>3</sup>	~\$72/yd <sup>3</sup> (initially)

# Anticipated Challenges

- ▶ Anticipated challenges:
  - High level (~35%) of cement replacement needed to reach carbon negativity
  - Potential low early-age strength
  - Energy intensity of drying black liquor
  - Risks associated with scaling of SAFFiRE (corn ethanol to SAF) process



Black liquor



Black liquor ash



# Tech to Market Plan

- ▶ Potential final products:
  - CO<sub>2</sub>-enhanced SCMs marketed and sold by Carbon Upcycling
  - Ready-mix concrete product marketed and sold by concrete suppliers
- ▶ Potential early-stage market:
  - Construction 3D printing (3DCP)
  - More likely to be early adopters
  - 3DCP mixes are typically high cement content
- ▶ Industrial Advisory Committee:
  - Traditional players: US Concrete, NRMCA
  - Arch. + Eng.: EUA, Pond & Co., SOM
  - 3DCP: Emergent 3D, Alquist 3D
  - Biomass: SAFFiRE/D3MAX
  - Seeking: standards, masonry/finishing



Source: <https://www.flexicon.com/Materials-Handled/Fly-Ash.html>



Source: <https://materialdistrict.com/article/turning-waste-concrete-into-3d-printed-public-furniture/>